# ケルビンプローブ顕微鏡/走査型容量原子間力顕微鏡による光触媒の表面活性計測

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課題: 触媒上のすべての担持金属は還元サイトとして機能しているのか？

実験結果
1, 触媒担持金属上において還元反応に寄与する電荷を直接可視化した。
2, 粒子内の電荷密度分布は一様ではなく、担持金属と触媒基板との均質な接合形成の重要性を示唆

## Principle of Kelvin-probe Force Microscopy (KPFM)

- KFM is based on Electrostatic Force (ESF) Detection.
- KFM signal is Effected by Band-Bending and Surface States.

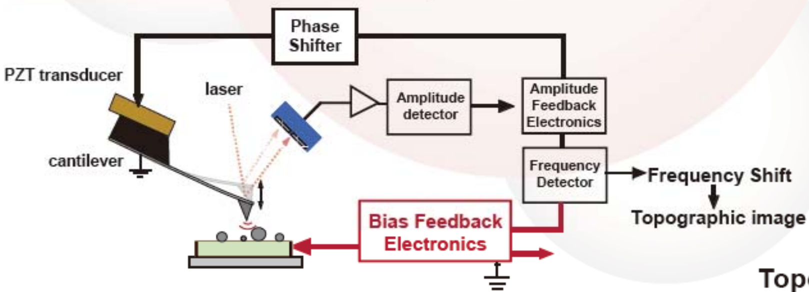
$$U = \frac{1}{2}CV^2$$

$$F = \frac{\partial U}{\partial z} = \frac{1}{2}\frac{\partial C}{\partial z}V^2 \Leftarrow V = V_{dc} + V_{ac}\cos\omega t$$

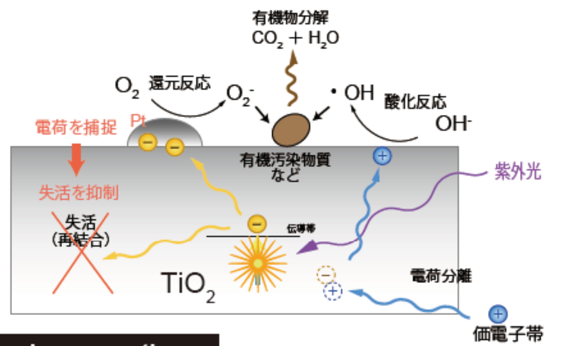
$$F = \frac{1}{2}\frac{\partial C}{\partial z}\left[(V_{dc}+V_{cpd})^2 + 2(V_{dc}+V_{cpd})V_{ac}\cos\omega t + V_{ac}^2\cos^2\omega t\right]$$

$$F = \frac{1}{4}\frac{\partial C}{\partial z}(V_{ac}^2 + V_{ac}^2\cos 2\omega t) \Leftarrow V_{dc} = -V_{cpd}$$

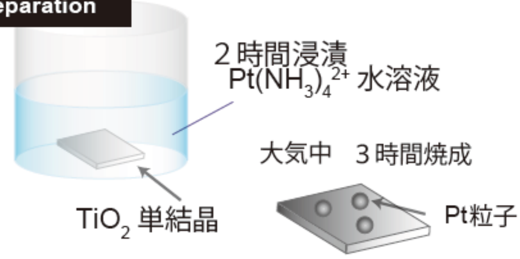
## Setup for KPFM



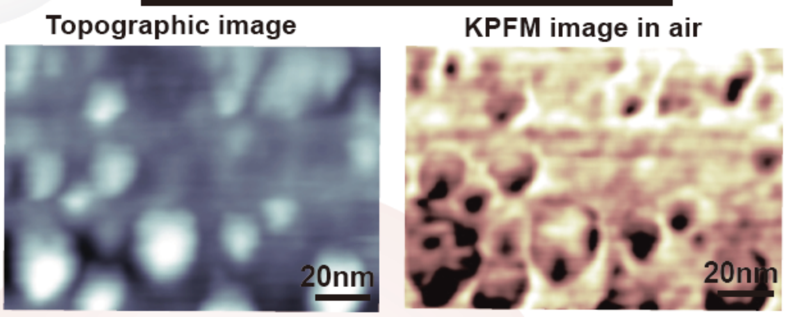

## Mechanism of photo-catalysis




## Sample preparation




## Experimental data of KPFM




***Unhomogeneous distribution of contact potential difference is visualized inside Pt nano-particles.***

***Vac = 2.5 V***

## Principle of Scanning Capacitance Force Microscopy (SCFM)

Scanning Capacitance Force Microscopy (SCFM)

$$\frac{\partial C(V,z)}{\partial z} \cong \frac{\partial C(V_{dc},z)}{\partial z} + \frac{\partial^2 C(V_{dc},z)}{\partial z \partial V}V_{ac}\cos\omega t$$

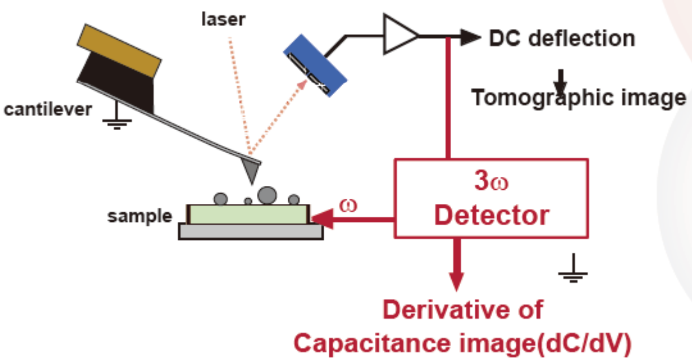
$$F = \frac{1}{4}\left[\frac{\partial C(V_{dc},z)}{\partial z} + \frac{\partial^2 C(V_{dc},z)}{\partial z \partial V}V_{ac}\cos\omega t\right](V_{ac}^2 + V_{ac}^2\cos 2\omega t)$$

$$F_{3\omega} = \frac{1}{8}\frac{\partial^2 C(V_{dc},z)}{\partial V \partial z}V_{ac}^3\cos 3\omega t$$

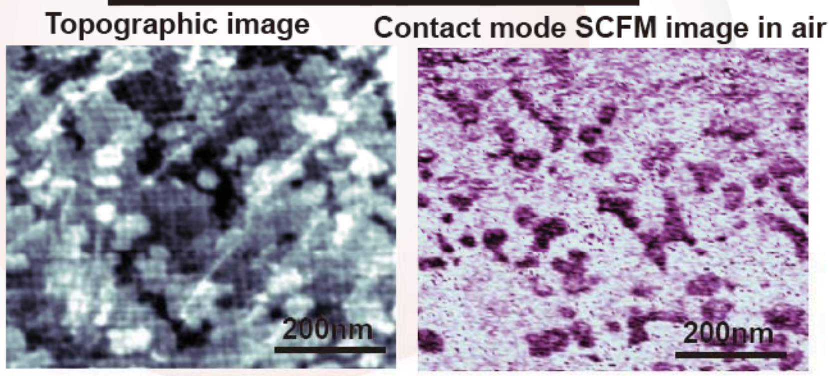
Amplitude reflects dopant concentration.
Phase reflects dopant species.

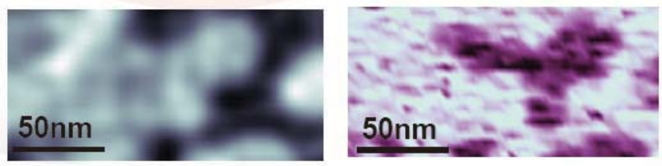
*K. Kobayashi et al., Appl. Phys. Lett. 81, 2629 (2002).*
*K. Kimura et al. Appl. Surf. Sci. 201, 93 (2003).*

## Setup for SCFM




## Experimental data of SCFM




***Vac = 6.5 V***

***SCFM can identify the locations of Pt nano-particles on unhomogeneous surface structure.***

今後: 動作中での計測
担持金属と触媒基板との接合形成法
担持金属の形状の最適化へフィードバック